THE CONTROL OF THE PINE REPRODUCTION WEEVIL, IN BRUSHFIELD PLANTINGS ON THE ELDORADO AND LASSEN NATIONAL FORESTS, BY THE USE OF DDT SPRAYS APPLIED FROM A HELICOPTER

Season of 1950

By

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and

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INTRODUCTION

The pine reproduction weevil, Cylindrocopturus eatoni Buch., still continues to rank as insect enemy No. 1 in brushfield plantings in northern California. It was responsible for the almost complete destruction of a large brushfield planting near Big Springs on the Lassen National Forest from 1938 to 1940. It very seriously threatened portions of the Mt. Shasta brushfield planting on the Shasta National Forest, and the Burney Springs planting on the Lassen in 1946. Experimental control action was initiated in both of these fields during the spring of 1947, using a variety of machines and formulas. One portion of this experiment was the use of aircraft of the fixed-wing type applying DDT at the rate of one and two pounds per acre in one and two gallons of diesel oil in the Shasta field. Of the various machines tested it was found that the aircraft gave the most efficient control. These tests showed that this spray control was very satisfactory in reducing the weevil population by about 90 percent and in reducing the loss by about 95 percent. Periodic checks have been made in both of these fields since the spray was applied and there was very little sign of renewed activity until the spring of 1950 when it was found that another serious epidemic was developing in portions of the Burney Springs planting where no control action had been taken in 1947. A check of the Mt. Shasta field, at the same time showed practically no activity. In the fall of 1947, J. M. Miller of the Forest Insect Laboratory and John Buck of the U. S. Forest Service, found heavy killing by the weevil of planted trees in the Plummer Ridge brushfield planting on

Gibson.....
Johnson...1/28...
Terrell.....
Trostle.....
Denton.....
Evenden.....
.....
.....

the Eldorado National Forest. This area was checked again in the late spring of 1950 and additional infested trees were found. From evidence in both the Burney Springs and the Plummer Ridge fields it was found that the number of infested trees had increased from eight to ten-fold over that for the previous season, and all indications pointed to heavy increases in 1950 unless control action was taken. Control action was recommended to the U. S. Forest Service by Hall[1/] on May 3, 1950. The recommendation was that a helicopter be used in this control job on an experimental basis. This recommendation was given immediate favorable action by the Forest Service. Bids were advertised on May 11 and were awarded to the A. F. Helicopters, Inc. on May 22. This was followed by a working plan by Hall[2/] on June 5 covering the proposed project.

1/ Control Recommendations for the Reproduction Weevil in the Plummer Ridge and Burney Springs Brushfield Plantings. By Ralph C. Hall, Berkeley Forest Insect Laboratory Report, May 3, 1950.

2/ Working Plan for the Control of the Reproduction Weevil in Brushfield Plantings on the Lassen and Eldorado National Forests by the Use of the Helicopter. By Ralph C. Hall, Berkeley Forest Insect Laboratory Report, June 5, 1950.

COOPERATION AND PERSONNEL

This was a cooperative project between the U. S. Forest Service and the Forest Insect Laboratory. The Forest Service supplied all the spray materials, the helicopter, and labor for flagging the area and for the preparation of landing strips for the helicopter. The Forest Insect Laboratory provided the technical supervision of the project and will be responsible for the checking of the results. Dr. Ralph C. Hall was designated as project supervisor and was assisted by J. M. Miller, Walter Nelson and Albert S. Perry. Rangers J. S. Woolfolk, from the Hat Creek District on the Lassen, and G. I. Ramstad, from the Caldor District on the Eldorado, cooperated in supplying all the necessary labor and communication service.

CONTROL OBJECTIVES

The general control objectives on this project were twofold: (1) To kill as many of the adult weevils as possible after they had emerged and were active on the trees and brush, and prior to the time of oviposition, through a contact spray at the time of the spray application. (2) To give protection to the uninfested trees through the residual effect of DDT which was expected to remain on the foliage and to be toxic for a period of about two months.

TIMING OF THE SPRAY

The original plan for the timing of the spray was based on the application coinciding with the peak of the emergence of adult weevils. It became necessary to coordinate this job with the experimental 2-4-D spray project for the control of sage brush on the Eastern Lassen and the time

schedule for the weevil job was set ahead. This resulted in the DDT spray being applied well ahead of the peak of emergence and as a result the principal effect of the spray came through the residual effect and practically no effect from contact.

The Burney Springs field was sprayed on portions of three days, June 10, 11 and 12 and the Plummer Ridge field was sprayed on June 13. From rearing records, it appears that there had been no emergence in either field prior to the date of spraying. The first emergence record from the Burney Springs field was on June 14 with the peak of emergence about June 27, or more than two weeks after the spray was applied. It is estimated that the peak of emergence was about the same for the Plummer Ridge areas.

METHOD OF TREATMENT

In view of the experience gained on the airplane control job on the Shasta in 1947[3/], it was decided to use the same formula and rate of application for the helicopter job.

A. Formula

The formula used on these projects was as follows: 1 pound of DDT, technical grade, plus .333 gallons of ortho aquatic solvent, plus .667 gallons of diesel. This resulted in a 15 percent DDT concentration.

3/ The Control of the Pine Reproduction Weevil in Brushfield Plantings on the Shasta and Lassen National Forests for the Season of 1947. By Ralph C. Hall, Berkeley Forest Insect Laboratory Report, July 19, 1948.

B. Aircraft

A Bell-B-3, Model 47D helicopter, belonging to the A. F. Helicopters, Inc. was used in this job. See Figure 1. This had a rated horse power of 178.

1. Spray Apparatus: This ship was equipped with two hoppers, each with a capacity of 25 gallons. The power for the spray rig was from a centrifugal gear-driven pump supplying 35 pounds pressure to 20, T type jet nozzles, fitted to two booms under the center of the ship. See Figure 2. An agitator kept the spray mixture well mixed during flight and when the spray was being dispersed.

2. Flight Data: The indicated air speed while spraying was 15 miles per hour at dosages of 1 pound per acre, and 30 miles per hour for dosages of 1/2 pound of DDT per acre. The effective width of the strip was determined to be about 66 feet as the result of several preliminary test runs over filter paper spaced at intervals of 16-1/2 feet at right angles to the line of flight. This width was used except in the case of dosages of 2 pounds of DDT per acre when the width of the strip was reduced to 33 feet. The pilot was kept oriented by a flagman at each end of his strip.

AREAS TREATED

A. Lassen National Forest

The area treated on the Lassen National Forest was a portion of the East Block of the Burney Springs Brushfield planting. All of block P-59-38 and portions of blocks P-55-37 and P-69-39 were treated. These were areas where the weevil was found to be causing serious damage in 1949. See Figures 3 and 4. A total of 546 acres were treated in this field, of which

Figure 1.--The Bell Model 47D, 178 hp. helicopter used in the Reproduction Weevil Control Project in Burney Springs and Plummer Ridge. This helicopter was equipped with two hoppers having a capacity of 25 gallons each. A centrifugal gear-driven pump produced 35 pounds of pressure to the two side booms, each with ten T-jet type nozzles.

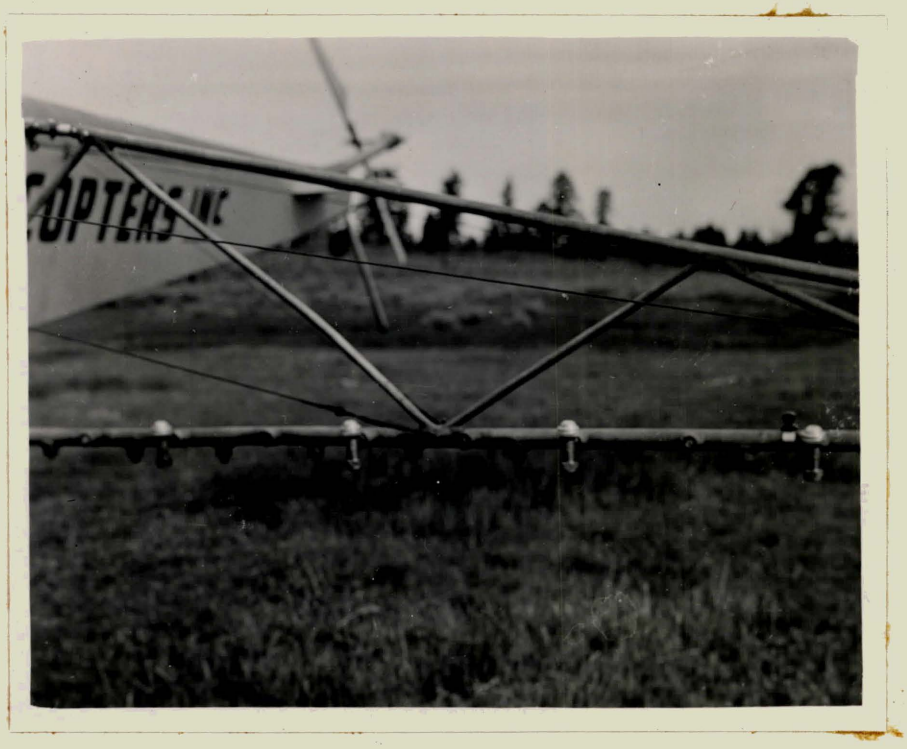


Figure 2.--A view of one of the two spray booms showing the type of nozzle and arrangement.

100 were treated at a dosage of 1/2 pound of DDT per acre and the balance at 1 pound per acre. The Burney Springs East Block is characterized by mixed manzanita and ceanothus brush averaging about 5 feet in height, with a few patches of volunteer Baker cypress averaging from 15 to 20 feet in height. The field is most gently rolling with a north-east exposure and having an average gradient of about 7 percent. The planting ranges in elevation from 4,600 to 5,200 feet. See Figures 3 and 4.

1. The Heliport. The heliport for the Burney Springs project was located about one mile east of Burney Springs on a sage brush flat at an elevation of about 4,600 feet. It was planned to use a port in the center of the field but prevailing wind conditions changed during the period of spray application and this port could not be used. See Figure 5.

2. Time of Treatment and Weather Conditions. The Burney Springs area was treated on portions of three different consecutive days, June 10, 11, and 12. The weather was far from ideal all during this period. The sky was overcast with heavy storm clouds all during the three-day period. It threatened to rain at almost any time and light showers, coupled with heavy winds, closed the project down on the first and second days. Wet brush delayed the start of the job on the third day until about noon. The sun did not shine at any time during the three days. Temperature factors, however, were favorable during most of the time. It ranged from 54 to 56 on the first day, from 32 to 41 on the second day, and from 47 to 54 degrees on the third day.

3. Application of the Spray. The pilot was able to fly most of this area at from 5 to 10 feet above the general canopy of the brush. The indicated air speed was about 15 miles per hour for all of this area. For the most part the area was flown on a contour basis. The first few strips

Figure 3.--A general view of the Burney Springs Brushfield. Picture taken along the east boundary at the junction of the road which bisects the area north and south. The solitary tree against the horizon in the left background is about the west boundary of the area sprayed. The men in the foreground are clearing a patch of brush for a heliport. This was not used because the prevailing wind during the period of spray application was consistently down the slope.

Figure 4

REPRODUCTION WEEVIL CONTROL PROJECT

BURNEY SPRINGS BRUSHFIELD PLANTING

EAST BLOCK

LASSEN NATIONAL FOREST

X - TREATED IN 1947

Y - TREATED IN 1950

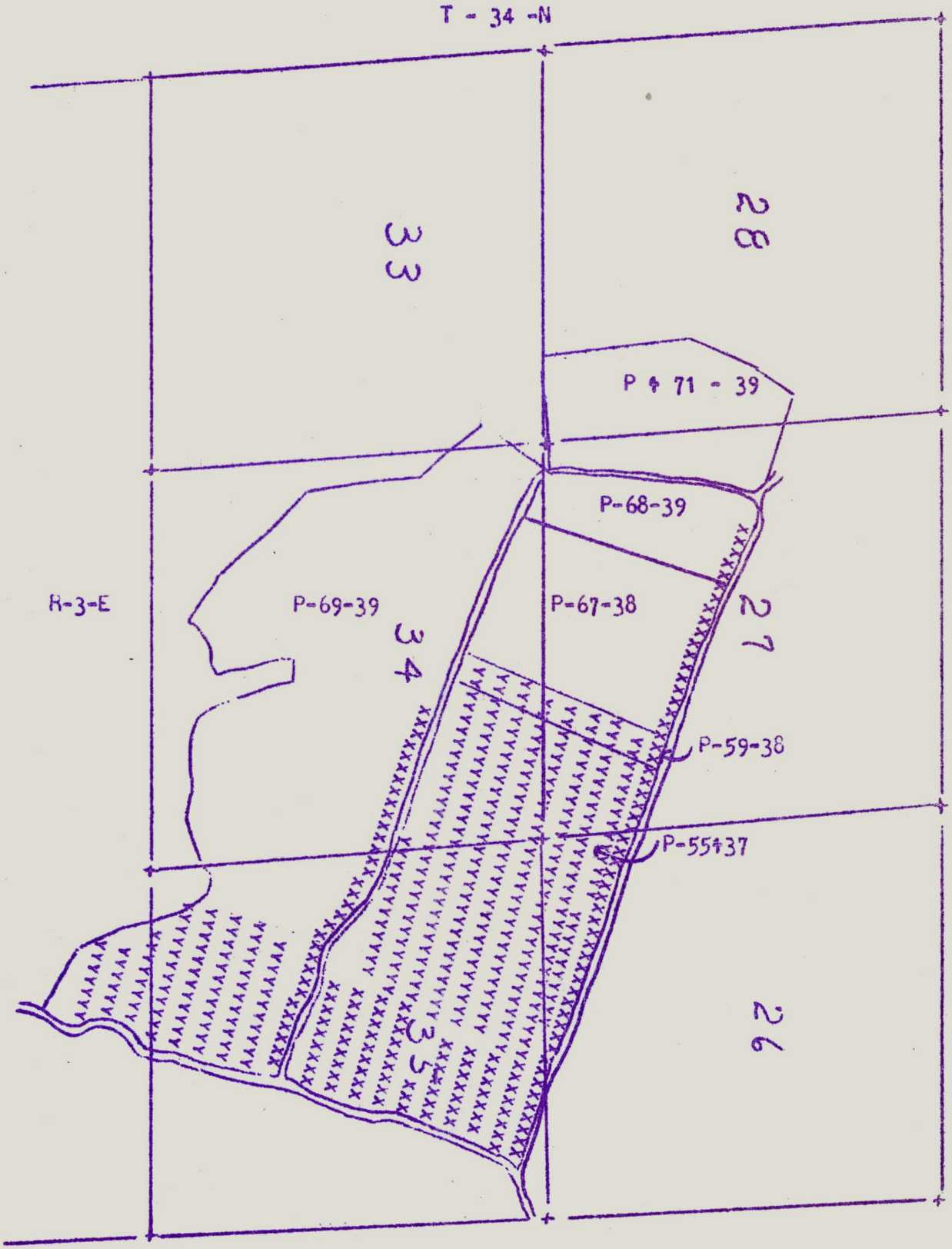


Figure 5.--The heliport for the Burney Springs Brushfield Project, located about one mile east of Burney Springs on a sage brush flat. Large barrels to the left contain diesel oil; small barrels at the right contain DDT concentrate. The weather station shelter housed a hygrothermograph and maximum and minimum standard Weather Bureau thermometers. Temperatures ranged from a minimum of 32 degrees to a maximum of 56 degrees F. during the application of the spray. The weather was overcast with heavy clouds during most of the spray period. There was no sun during the three days of spray application.

were flown down slope but this resulted in a lot of dead-heading and the balance of the area was covered on a contour basis. Twenty-five gallons of spray were carried in each load. The DDT was in concentrate form in drums containing 28 gallons. Sufficient concentrate to make 12-1/2 gallons was measured into each of two buckets and then poured into the two hoppers. Diesel oil was then pumped into the two hoppers until the 12-1/2 gallon level was reached. The drums of diesel were placed about ten feet apart and the pilot then set his ship down between the two barrels. See Figures 6 and 7.

Test strips were run at the start of the project to determine the optimum width at a height of about 5 feet above ground. Very effective coverage was obtained over a swath of 66 feet and this width was adopted as the standard for flight. This width was also adopted because it fitted in well with the planting spacing. With a spacing of a rod apart, the 66-foot width included 4 rows of trees.

Flying at from 5 to 10 feet above the general canopy of the brush resulted in what appeared to be excellent uniform coverage; with wind velocity of up to 12 miles per hour there appeared to be very little side drift of the spray. The action of the rotor blast drove the spray down into the brush and around the planted trees, and there appeared to be very little loss of spray through upward drift. See Table 1 and Figure 8, A, B, C, and D.

Figure 6.--The helicopter landing between the drums of diesel oil for convenient loading.

(A)

(B)

Figure 7.--Loading the spray in the helicopter. (A) The concentrate was measured out in two buckets, with enough concentrate in each to make 12-1/2 gallons. This was dumped into each of the two hoppers. (B) Diesel oil was then pumped into the hoppers to bring the level up to 12-1/2 gallons in each hopper. An agitator kept the spray material well mixed during the flight from the port to the field and during the time of the application of the spray.

Table 1.--Helicopter Time Report - Burney Springs Project.

Forest: Lassen Firm Name: A. F. Helicopters, Inc. Pilot: J. N. Newcomb

Type of Ship: Bell-B-3, Model 47D helicopter, 178 hp. N.C. License: 145-B

Project: Burney Springs Reproduction Weevil Control

Chemical: DDT Technical Grade Formula: 1 lb. DDT plus .333 gal. ortho aquatic solvent plus .667 gals. diesel

Dosage: 1/2 and 1 gal. per acre

Heliport: Burney Springs Sage Brush Flat - 1 mile east of Burney Springs

Date	Time Off Hr.	Time Off Min.	Time On Hr.	Time On Min.	Flying Time Min.	Temp. Deg. F.	Wind MPH	Load Gal.	Acres Treated
6/10	8	37	8	53	16	Ferry time Hat Creek R.S. to Burney Sprg.			
6/10	11	04	11	07	3	Testing swath width			
6/10	11	19	11	29	10	56	9-12	25	12
"	11	52	12	09	17	56	9-12	25	25
"	12	38	12	53	15	54	9-12	25	25
6/10		Closed down on account of rain 1:15 p.m.							
6/11	6	35	6	46	11	32	3	25	25
"	7	01	7	10	9	34	3	25	25
"	7	22	7	32	10	34	3	25	25
"	7	40	7	50	10	37	3	25	25
"	7	55	8	03	8	40	3-5	25	25
"	8	06	8	14	8	40	5	25	25
"	8	26	8	35	9	40	5	25	50
"	8	43	8	53	10	41	5-10	25	50
6/11		Closed down on account of rain and wind at 9:00 a.m.							
6/12	11	55	12	10	15	47	3-5	25	25
"	12	15	12	30	15	47	3-5	25	25
"	12	35	12	52	17	48	3-5	25	25
"	13	07	13	15	8	50	5-10	25	25
"	13	23	13	37	14	50	5-10	25	25
"	13	42	13	56	14	52	5-10	25	25
"	14	00	14	14	14	53	5-10	25	25
"	14	25	14	35	10	54	5-10	25	25
"	14	45	14	56	11	54	5-10	25	25
"	15	01	15	13	12	54	5-10	25	25
"	15	18	15	28	10	54	5-10	15	15
6/12	15	44	15	53	9	Ferry time Burney Springs to Hat Creek R.S.			
Total					260 time on job 25 ferry time			540	577

Planimetered area treated, acres	546
Acres treated per hour	126
Flying Cost 546 acres at $2.00 per acre	$1,092.00
Cost per hour	252.02

A

B

Figure 8.—Application of DDT spray from the helicopter. (A) Head-on view. (B) View from the rear. Note that the ship is flying very close to the level of the brush and that spray "hugs" the ground very effectively. The ship was from 5 to 10 feet above the canopy of the brush on these two flights.

C

D

Figure 8.--(C) Head-on view showing a slight drift of the spray to the left. This was next to the last strip run when the wind plus a light shower closed the operation down for that particular day. (D) Rear view, quartering showing the way the spray is forced down to the ground by action of the rotor blast. The height of the sh[illegible] on this run was about 15 feet above the general canopy of the brush [illegible] to the presence of scattered natural Baker Cypress reproduction.

B. Eldorado National Forest

The area treated on the Eldorado National Forest included two small plantings on Plummer Ridge. One of these, the east block, contained 15 acres; the other, the west block, contained 45 acres. The 15-acre block was treated at the rate of 1 pound of DDT per acre and the 45-acre block was treated at the rate of 2 pounds of DDT per acre. See Figure 9.

These fields were radically different from the Burney Springs planting. The Plummer Ridge plantings were small brushfields surrounded on all sides by tall timber. In contrast to the Burney Springs field with few obstacles, the Plummer Ridge fields were covered with all sorts of obstacles in the form of high oak brush, snags, and some scattered tall trees. See Fig. 10. The exposure of these two fields was north, with elevations ranging from about 4700 to 5000 feet, with the average gradient about 12 percent.

1. The Heliport. The heliport for the Plummer Ridge project was the top of a ridge about one mile east of the Plummer Ridge Guard Station, where the heavy brush had been removed covering an area of about 60 square feet. See Fig. 11.

2. Time of Treatment and Weather Conditions. The Plummer Ridge project was treated on June 13. The weather continued on a threatening basis, with air temperature ranging from 59 to 61 degrees and wind velocities ranging from 5 to 15 miles per hour.

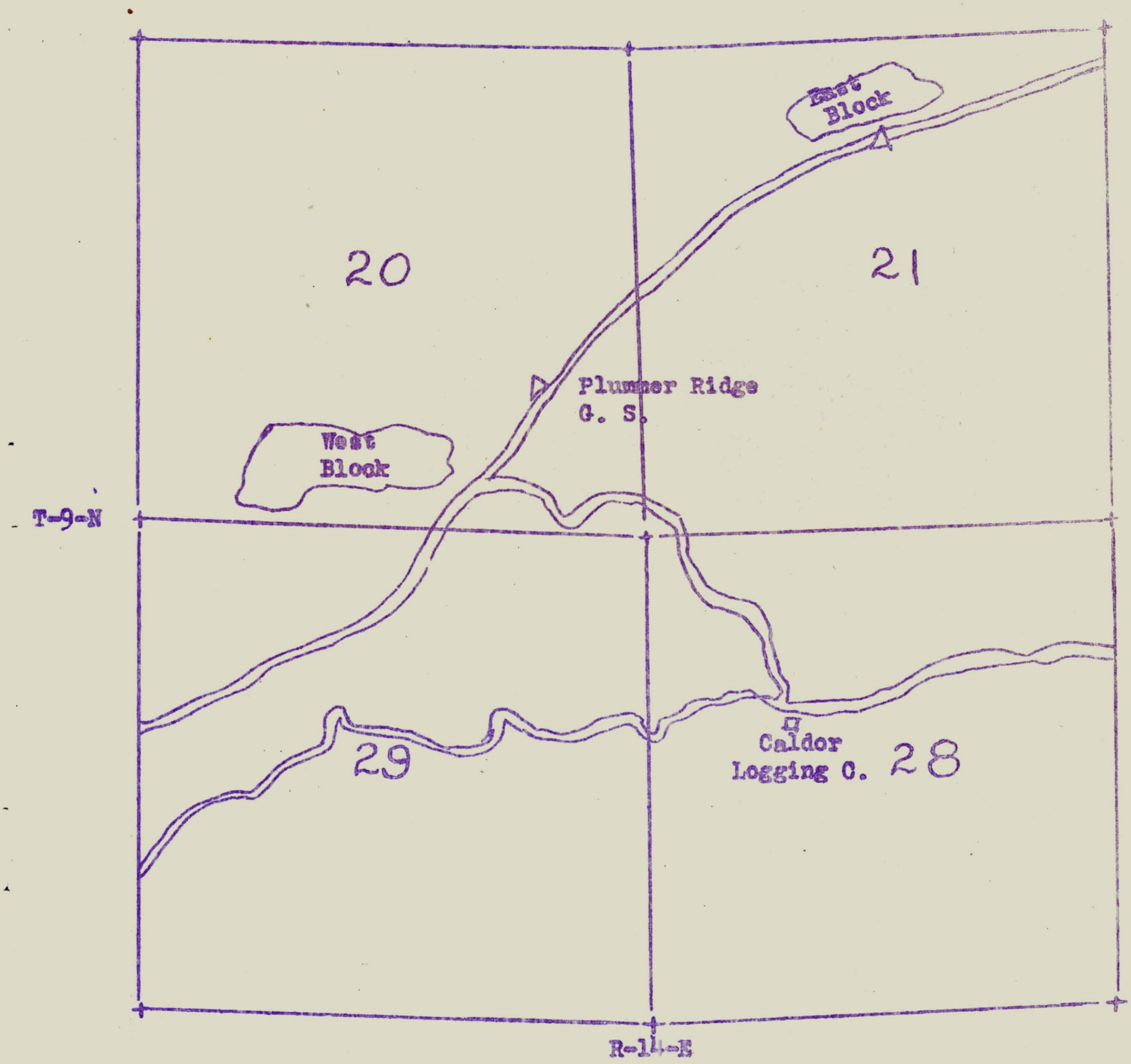
3. Application of the Spray. Because of the many obstacles in both these fields, the average height of flight above the general brush canopy was from 20 to 30 feet. The spray was applied on a contour basis into the prevailing wind which was blowing from the west. As a result of flying from 20 to 30 feet above the general canopy of the brush the coverage was not as uniform as in the Burney Field. Also there was noticeable upward drift of some of the spray material, although the rotor blast forced most of the spray material down into the brush and around the planted trees. See Fig. 10.

Figure 9

REPRODUCTION WEEVIL CONTROL PROJECT

PLUMMER RIDGE BRUSHFIELD PLANTING

P + 21 - 42
Eldorado National Forest



A

B

Figure 10.--Helicopter applying spray on the Plummer Ridge area. This field had many obstacles in the form of old snags, high oak brush, and tall trees, which made it impossible to fly close to the brush tops. (A) The plane is about 30 feet above the general level of the brush. (B) Here it is about 20 feet above. Note the way in which the spray is forced down by the rotor blades.

Figure 11.—The heliport for the Plummer Ridge Spray Project. This was located about one mile east of the Plummer Ridge Guard Station.

GENERAL PERFORMANCE AND COST

It was generally agreed by all the personnel working on this project that the pilot, J. N. Newcomb, did an excellent job of handling his ship and keeping on course. This was an experimental project and the first time the helicopter had been used for the control of a forest insect pest in California. The performance of this type of a ship lived up to all of the expectations for it. As expected, the rotor blast forced most of the spray down well into the brush cover and around the planted trees. In the Burney Springs field the calculated acreage covered was 577 compared to 546 planimetered acres. The 546 acres were treated in 4-1/3 hours or at a rate of 126 acres per hour. The total cost was $252.02 per hour or $2.85 per acre. This per acre figure was broken down as follows: Helicopter, $2.00, spray materials, $.60, labor $.25. See Tables 1 and 3.

In the Plummer Ridge project, the calculated acreage was 60 andthe planimetered acreage was the same. The 60 acres were treated in 1.23 hours or at a rate of 48.7 acres per hour. The total cost was $97.32 per hour or $3.07 per acre. This per acre figure was broken down as follows: Helicopter, $2.00 per acre, spray materials; $1.07, labor contributed. See Tables 2 and 3.

Table 2.--Helicopter Time Report - Plummer Ridge Project

Forest: Eldorado Firm Name: A. F. Helicopters, Inc. Pilot: J. N. Newcomb

Type of Ship: Bell-B-3, Model 47D, helicopter, 178 hp. N.C. License: 145-B

Project: Plummer Ridge Reproduction Weevil Control Date: June 13, 1950

Chemical: DDT Technical Grade Formula: 1 lb. DDT plus .333 gal. ortho aquatic solvent plus .667 gals. diesel

Dosage: 1 and 2 gals. per acre

Heliport: Plummer Ridge - 1 mile east of Plummer Ridge Guard Station

Time Off Hr.	Time Off Min.	Time On Hr.	Time On Min.	Flying Time Min.	Temperature Degrees F.	Wind MPH	Load Gals.	Acres Treated
11	10	11	22	12	Ferry time in from Dew Drop			
12	40	12	50	10	59	5	15	15
13	40	13	50	10	59	5-7	15	7.5
14	00	14	10	10	59	5-7	15	7.5
14	16	14	27	11	60	7-10	15	7.5
14	38	14	50	12	61	7-10	15	7.5
14	56	15	08	12	59	10-15	15	7.5
15	15	15	26	9	59	15	15	7.5
16	00	16	12 (est)	12	Ferry time back to Dew Drop			
Total				74 time on job 24 (est) ferry time			105	60

Planimetered area, acres	60
Acres treated per hour	48.7
Flying cost, 60 acres at $2.00 per acre	$120.00
Cost per hour	97.32

Table 3.--Control Costs

Burney Springs Project - Lassen National Forest	
Spray Material	
500 lbs. of DDT technical grade plus 166-2/3 gals of ortho aquatic solvent, F.O.B. Burney	$ 253.05
375 gals. diesel oil at $.16	60.00
10 lbs. dye at $1.58	15.80
Total spray materials	328.85
Helicopter cost, 546 acres at $2.00 per acre	1,092.00
Labor cost, heliport preparation, flagging, etc.	135.34
Total Expenditure	$1,556.19
Per Acre Cost - 546 acres treated:	
Helicopter	2.00
Spray materials	.60
Labor	.25
Total per acre cost	2.85
Cost per gallon of spray	.658
Plummer Ridge Project - Eldorado National Forest	
Spray Material	
100 lbs. of DDT technical grade plus 33-1/3 gals of ortho aquatic solvent, F. O. B. Placerville	$ 48.75
100 gallons diesel oil at $.1552	15.52
Total spray materials	64.27
Helicopter cost, 60 acres at $2.00 per acre	120.00
Labor cost (contributed)	
Total Expenditure	$184.27
Per Acre Cost - 60 acres treated:	
Helicopter	2.00
Spray materials	1.07
Labor (contributed)	
Total cost per acre	3.07
Cost per gallon of spray	.643

CHECKING THE DISTRIBUTION OF THE SPRAY

The distribution of the spray was checked through a series of glass slides, 3 x 4 inches, spaced 16-1/2 feet apart at right angles to the line of flight. These were placed on wooden stands about three feet above ground, or just below the general canopy of the brush. See Figure 12. These plates were placed in specially constructed file boxes after exposure and later taken to the Laboratory for analysis of spray deposit. Thirty plates were used in the Burney Springs field and 18 in the Plummer Ridge Field. The Schechter-Haller method of analysis was used in this study. Droplet size analysis is presented in Table 4 and Figure 13.

A. Burney Springs Field

The effective DDT deposit reaching the ground averaged about 57 percent or .57 per acre. See Table 5. By individual swaths, the average deposit reaching the ground at the center was 1.014 lbs. per acre. At the 1/4-chain station on the west it was .497 lbs. per acre and .668 lbs. per acre at the 1/4 chain station on the east. At the 1/2 chain station to the west it was .269 lbs. per acre and .305 lbs. per acre at the east station. See Table 7.

B. Plummer Ridge Field

In the Plummer Ridge experiment both the total amount and the percentage of effective spray were considerably reduced over that for the Burney Springs area. In the east planting, 1 lb. per acre was applied and the average recovery was .291 lbs. per acre or 29.1 percent. In the west field, 2 lbs. per acre were applied and the average recovery was .392 lbs. per acre or 19.6 percent. See Table 6. The sampling error for deposit recovery was quite high in both of these fields and these average figures can be considered only approximate. As will be shown in the latter part of this report, the average recovery of DDT, as shown from the glass slides, showed a close association with subsequent weevil population, amount of needle feeding and

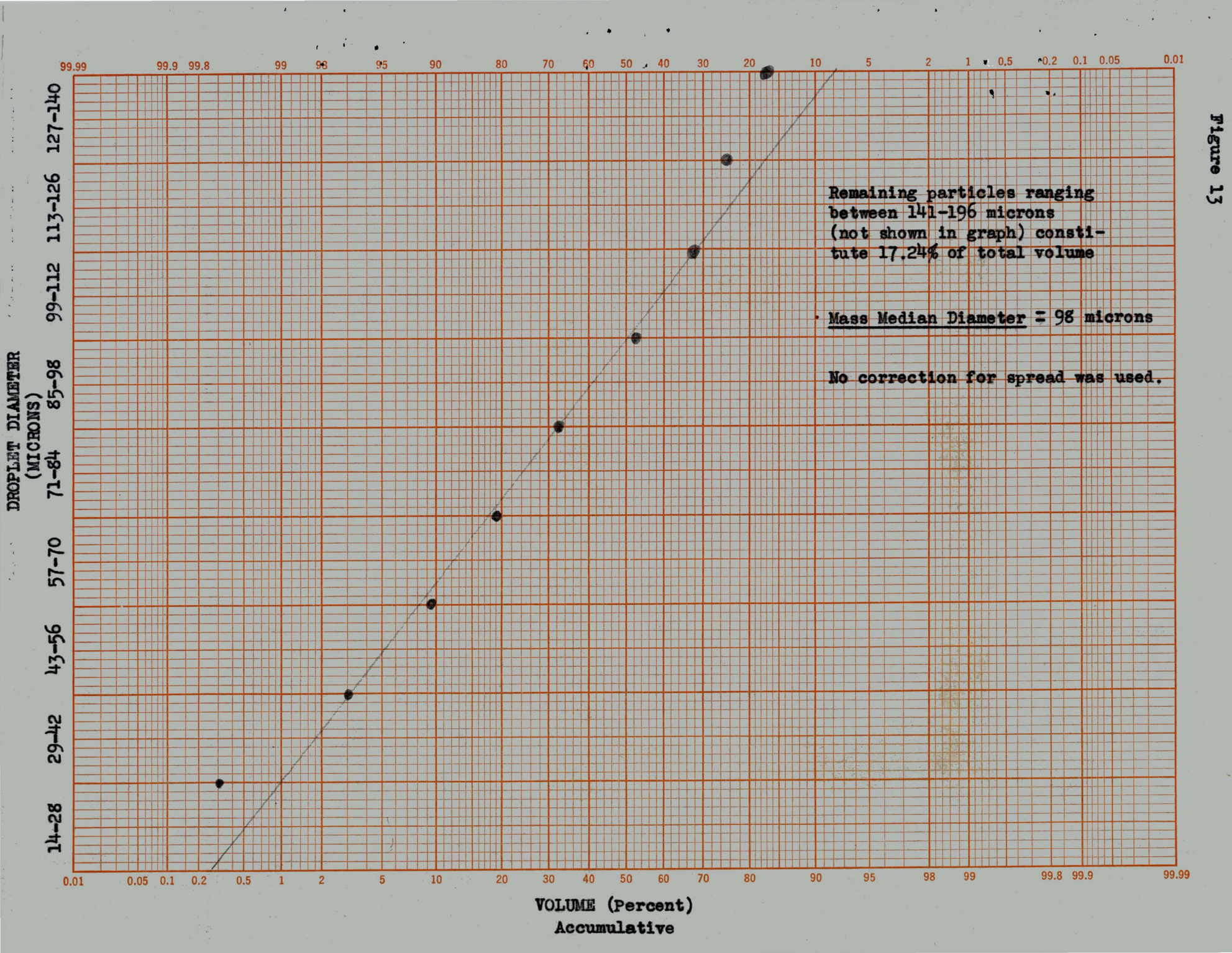

99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
127-140
113-126
99-112
85-98
71-84
57-70
43-56
29-42
14-28
DROPLET DIAMETER (MICRONS)
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99
VOLUME (Percent) Accumulative
Remaining particles ranging between 141-196 microns (not shown in graph) constitute 17.24% of total volume
Mass Median Diameter = 98 microns
No correction for spread was used.

Figure 13

only approximate. As will be shown in the latter part of this report, the average recovery of DDT, as shown from the glass slides, showed a close association with subsequent weevil population, amount of needle feeding, and reduction in loss. See Table 3.

Figure 12.--Arrangement of the glass plates used to measure the amount of spray deposit. These plates were supported on small wooden platforms about three feet from the ground. These plates were spaced at intervals of 16-1/2 feet at right angles to the line of flight. One of the two flagmen is shown in the center foreground. The trees in the foreground are Baker Cypress.

Table 4.--Droplet Size Analysis on Magnesium Oxide Coated Slides.

(d) Diameter (Microns)	(v) Volume $1/6\pi D^3$	(n) No. of Droplets	(v)x(n) Volume of Droplets	($\frac{v}{V}$) Percent of Total Vol.
14	1,435.1	8	11,480	0.0038
21	4,843.5	34	164,679	0.054
28	11,480.9	68	780,701	0.26
35	22,423.6	120	2,690,832	0.89
42	38,748.0	130	5,037,240	1.66
49	61,530.4	130	7,998,952	2.64
56	91,847.2	126	11,572,747	3.82
63	130,774.5	100	13,077,450	4.32
70	179,389.0	90	16,145,010	5.33
77	239,766.7	76	18,222,269	6.02
84	309,984.2	70	21,698,894	7.17
91	394,117.6	66	26,011,761	8.60
98	492,243.4	64	31,503,577	10.41
105	605,437.8	42	25,428,387	8.40
112	734,777.3	32	23,512,773	7.77
119	881,338.1	14	12,338,733	4.08
126	1,046,196.6	10	10,461,966	3.46
133	1,230,429.2	10	12,304,292	4.07
140	1,435,112.0	8	11,480,896	3.79
147	1,661,321.5	4	6,645,286	2.20
154	1,910,134.0	1	1,910,134	0.63
161	2,182,625.0	3	6,547,875	2.16
168	2,479,873.5	3	7,439,620	2.46
175	2,802,953.1	3	8,408,859	2.78
182	3,152,941.1	2	6,305,882	2.08
189	3,530,913.6	2	7,061,827	2.33
196	3,937,947.3	2	7,875,894	2.60
Total			302,638,016	100.00

Table 5. Burney Field. Colorimetric Analysis of DDT Deposits. (Schechter-Haller method)

Sample No.	Code No.	Micrograms DDT per slide	Recovery lbs/acre	Percent Recovery
1	1/4 E	950	1.092	109.2
2	1/2 W	290	0.333	33.3
3	1/2 E	36	0.041	4.1
4	1/4 W	90	0.103	10.3
5	1/2 E	150	0.172	17.2
6	1/4 W	96	0.110	11.0
7	1/4 E	180	0.207	20.7
8	1/2 W	232	0.267	26.7
9	C	1,280	1.472	147.2
10	C	444	0.510	51.0
11	C	1,170	1.345	134.5
12	1/2 W	430	0.494	49.4
13	C	570	0.653	65.3
14	1/2 W	105	0.120	12.0
15	1/4 W	930	1.069	106.9
16	1/4 E	350	0.402	40.2
17	1/4 W	280	0.322	32.2
18	1/4 E	280	0.322	32.2
19	1/4 W	300	0.345	34.5
20	1/2 E	210	0.241	24.1
21	1/2 W	115	0.132	13.2
22	1/2 C	1,120	1.288	128.8
23	1/4 W	910	1,046	104.6
24	1/2 E	110	0.126	12.6
25	C	710	0.816	81.6
26	1/4 E	1,180	1.357	135.7
27	1/4 E	545	0.626	62.6
28	1/2 E	820	0.943	94.3
Total			15.954	
Average			.570	57.07 ± 8.5

Table 6. Placerville. Colorimetric Analysis of DDT Deposits. (Schechter-Haller method)

EAST FIELD (1 lb/acre)				WEST FIELD (2 lbs/acre)			
Sample No.	Micrograms DDT per slide	Recovery lbs/acre	Percent Recovery	Sample No.	Micrograms DDT per slide	Recovery lbs/acre	Percent Recovery
1	402	0.462	46.2	1	225	0.258	12.9
2	390	0.448	44.8	2	216	0.248	12.4
3	564	0.648	64.8	3	130	0.149	7.5
4	145	0.166	16.6	4	328	0.377	18.8
5	0	0	0	5	225	0.258	12.9
6	22	0.025	2.5	6	174	0.200	10.0
7	64	0.073	7.3	7	654	0.752	37.6
8	670	0.770	77.0	8	780	0.897	44.8
9	24	0.027	2.7				
Total		2.619				3.139	
Average		.291	29.1 ± 9.8			.392	19.6 ± 4.9

Table 7. Distribution of Spray in 66-foot Swaths. Burney Field

Sample	33' W.	16-1/2' W. Recovered	Center Pounds	16-1/2' E. Per Acre	33' E.
A	.333	.103	1.472	1.092	.041
B	.267	.110	.510	.207	.172
C	.494	1.069	1.345	.402	.241
D	.120	.345	.653	.322	.126
E	.132	1.046	1.288	1.357	.943
F		.322	.816	.626	
Total	1.346	2.995	6.084	4.006	1.523
Average	.269	.499	1.014	.668	.305

BIOASSAY OF THE RESIDUAL EFFECTIVENESS OF DDT ON CYLINDROCOPTURUS EATONI, BUCH., UNDER LABORATORY CONDITIONS

This preliminary test was designed for the study of dosage-mortality relationships on treated glass surfaces under laboratory conditions. The desired concentrations of DDT solutions in acetone were placed in Petri dishes, the acetone evaporated by passing a light stream of air over the dish and allowing to stand for a period of 30 minutes. Consequently, 20 weevils were placed in each dish, and the latter was covered with cheese cloth. The insects were exposed to the residue for one hour after which they were transferred to clean pint jars provided with fresh pine needles as food. Mortality counts were taken at the end of 24 and 48 hours. See Figure 14.

The data obtained indicated that under the above conditions, 18 micrograms/sq. in. of DDT are required to give 50 percent kill and about 74 micrograms/sq. in. for 90 percent mortality. Calculated in terms of lbs./acre, these values would correspond to 0.25 lbs./acre for an LD_{50} and 1.0 lb/acre for an LD_{90}.

Glass surface did not prove to be very satisfactory for this insect since it did not afford a firm foothold and, therefore, prevented the free movement of the insects in all directions.

Qualitative tests showed plywood panels to be more satisfactory surfaces for testing. It appears that smaller quantities of the insecticide than those obtained above would be required for good control.

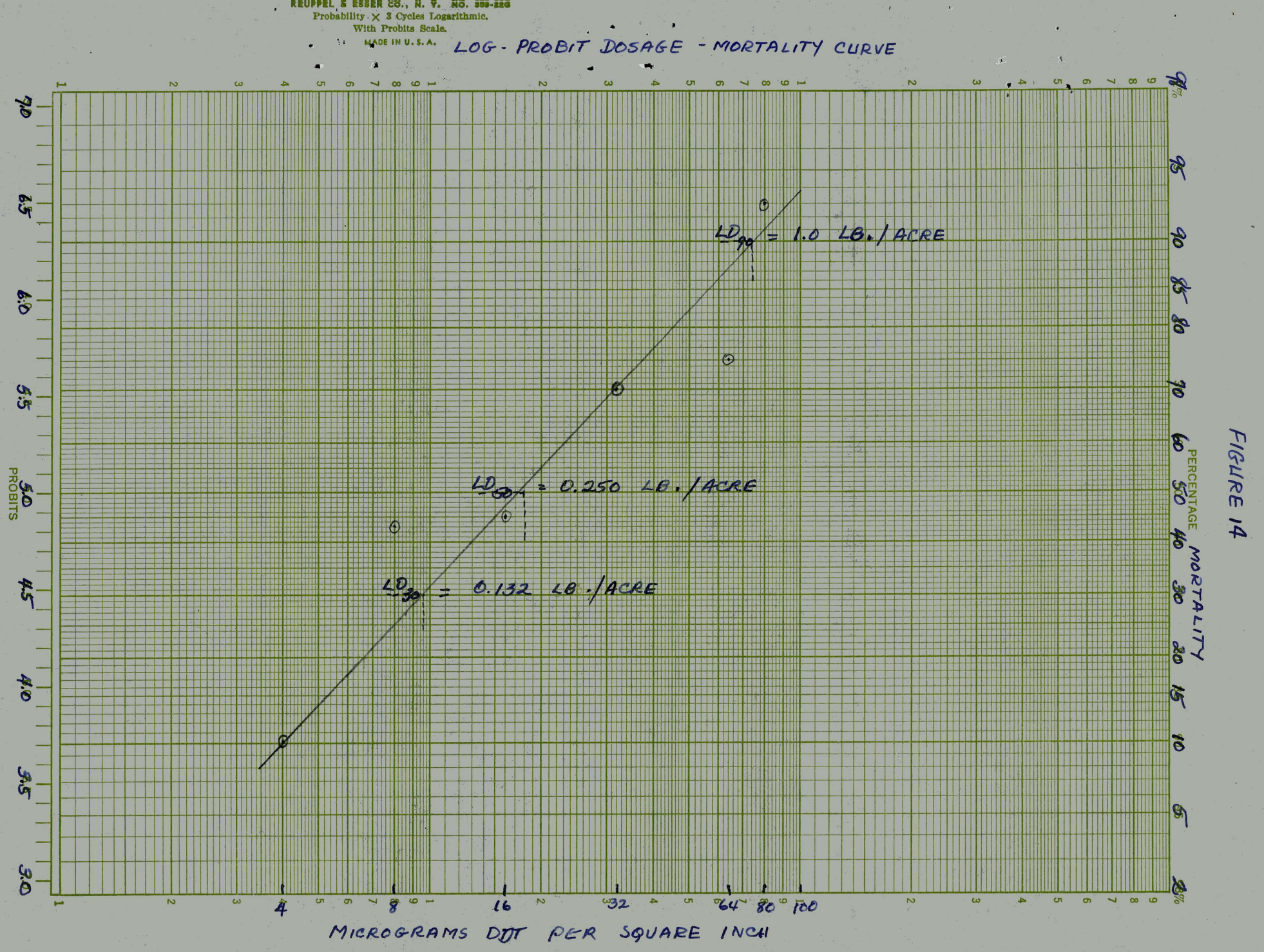

REUPPEL & ESSER CO., N. Y. NO. 358-22G
Probability × 3 Cycles Logarithmic.
With Probits Scale.
MADE IN U. S. A.
LOG - PROBIT DOSAGE - MORTALITY CURVE
LD_{99} = 1.0 LB./ACRE
LD_{50} = 0.250 LB./ACRE
LD_{30} = 0.132 LB./ACRE
PROBITS
PERCENTAGE MORTALITY
MICROGRAMS DDT PER SQUARE INCH
4
8
16
32
64
80
100

FIGURE 14

Table 8. Bioassay - Petri dish method.

Micrograms per sq. in.	Micrograms per Petri dish	No. of Weevils	No. dead 24 hrs.	No. dead 48 hrs.	% Mortality 24 hrs.	% Mortality 48 hrs.	Corrected Mortality % - 48 hrs.
4	50	20	0	2	0	10	0
8	100	20	6	8	30	40	30
40	500	20	8	10	40	50	40
80	1000	20	20	-	100	-	100
	Check	20	1	2	5	10	
4	50	20	2	2	10	10	0
8	100	20	6	8	30	40	30
16	200	20	6	8	30	40	30
32	400	20	10	14	50	70	60
64	800	20	12	14	60	70	60
80	1000	20	18	18	90	90	80
	Check	20	0	2	0	10	
8	100	10	3	5	30	50	30
16	200	10	4	5	40	50	30
32	400	10	5	7	50	70	50
64	800	10	7	8	70	80	60
80	1000	10	8	9	80	90	70
	Check	10	1	2	10	20	

METHOD OF EVALUATING CONTROL RESULTS

There were four principal methods used in evaluating control results in this experiment. (A). A population density study of adult weevils in the fields following the application of the spray. (B). Calculation of the amount of feeding on the needles the year previous and the season following the application of the spray. (C). Testing of sprayed trees or portions thereof through caging with adult weevils to determine the residual effect of the DDT spray. (D). Surveys of the number of trees killed the year previous and the year following the application of the spray.

(A). Population Studies. Periodic samplings of the Burney Springs Planting for weevil population were made following the application of the spray. These were made on the following dates: July 3, July 12, July 24, and July 28. There was only one sampling in the Plummer Ridge field, which was on July 31. Population density for this study was obtained through beating methods. It was found in the 1947 study that this method compared very favorably with the cone collar method and was much less time-consuming. It was found that the most satisfactory method of collecting weevils in a net was to bend the tree over and place the top portion in the net and then hit the tree a sharp blow. This usually dislodged all living weevils at one stroke.

(B). Feeding by Adults on Needles. The adult weevils do considerable feeding on needles prior to the time that they start the oviposition on the stems. Wherever a weevil feeds on a needle there is left a tell-tale puncture around which forms a discolored ring. It is therefore very easy to determine the amount of feeding on needles by counting the number of

discolored rings. For the purpose of evaluating the number of weevils present in each field, a sampling was made of the feeding punctures on ten needle fascicles per tree for the 1949 and 1950 seasons.

(C). Testing of Residual Effect of the DDT Spray. The residual effect of the DDT spray was determined by caging potted trees which had been placed in the field at the time of spraying and then taken to the laboratory and caged with live weevils. This method was used in the Plummer Ridge Field. Another method was the collection of portions of planted trees which had been sprayed, then placing them in jars of water and caging them with live weevils. This was the method used in the Burney Springs Field.

(D). Survey of Weevil Damage. The ultimate test of the effectiveness of the DDT spray was the reduction in the number of trees killed by the weevil, and involves the sampling of trees killed in 1949 and those killed in 1950 to determine the amount of loss reduction brought about by the action of the spray.

CONTROL RESULTS

It is possible at this time to report on all phases of the control results. These include population reduction, reduction in feeding on the needles, and the residual effect of DDT on the adult weevil and loss reduction in planted trees brought about as the result of spray action.

A. Reduction in Weevil Population. From population checks in the untreated area of the Burney Springs Field in 1947 it was found that the average population per tree was about 50 weevils per tree during the early summer period. In 1950 we left no areas to serve as checks so that we

have no reliable method for evaluating what appeared to be a very drastic reduction in weevil population brought about as the result of spraying. From a small sample of eight trees caged to obtain adult weevils it was found that the average emergence per tree was 115 weevils. In some of the heavily infested portions of the Burney springs field the 1949 loss was 25 percent of the planted stands. This would indicate very heavy weevil population on the remaining trees. Practically all of the sampling for weevil population was carried on in areas where heavy loss had occurred in 1949. These results showed an apparent very drastic reduction in weevil population in the Burney Springs field. See Table 9. Of a total of 208 trees sampled only 26 weevils were found, or .13 weevils per tree. Another way to express this would be about one weevil for each 10 trees. When it is considered that the potential population was from 20 to 50 weevils per tree this apparent reduction in loss is very gratifying.

The results in the Plummer Ridge planting were not as striking as those for the Burney Springs field but they still were very satisfactory. The average population in the latter field was found to be about .5 weevils per tree or one weevil for every two trees. See Table 9.

B. Reduction of Feeding on Needles. A count of the feeding punctures on 10 fascicles of needles was made on 80 trees in the Burney Springs Field for both the 1949 and 1950 seasons of activity. As a result, it was found that there had been 988 feeding punctures in 1949 compared to only 7 in 1950. The results for the Plummer Ridge field for 25 trees in each block was 725 feeding punctures in 1949 in the East Block, compared to only 18 in 1950. In the West Block there were 350 feeding punctures in

1949 compared to only 8 in 1950. This is further evidence of a greatly reduced population in both fields, presumably brought about as the result of spraying with DDT. See Table 10.

C. Residual Effect of DDT under Laboratory Control.

1. Burney Springs Field. The residual effect of DDT following spraying in the Burney Springs field, was obtained through the collection of twigs from sprayed trees and placing these in a jar of water enclosed in a cheesecloth cage. Approximately 30 freshly-emerged weevils were placed in these cages and mortality counts were taken at 24-hour intervals for a period of 72 hours. This was the same system used in 1947, but in the 1950 tests larger cages were used. This part of the test for the Burney Springs experiment was rather dissappointing, due to the failure of the weevils to cooperate. In many cases the adults would crawl up on the sides of the cages and never go near the caged foliage. Twigs from three sprayed trees in the open, three sprayed trees protected by brush, and three trees with no spray were used in the initial test. The results were as follows: the three control trees with no spray, 53 percent mortality; the three trees partly protected by brush, 77 percent mortality; and the three trees in the open, 88 percent mortality. It was planned to replicate this experiment but it was impossible to obtain additional weevils for the test.

Table 9. Adult Weevil Population in Burney Springs and Plummer Ridge Brushfields Following Application of DDT Spray.

Date	No. Trees Sampled	Number of Adult Weevils Total	Per Tree
BURNEY SPRINGS FIELD			
7/3	42	2	.05
7/12	51	6	.12
7/24	35	5	.14
7/28	80	13	.16
Total	208	26	.13 ± .02
PLUMMER RIDGE FIELD			
7/31			
East Block	25	13	.52
West Block	25	11	.44
Total	50	24	.48 ± .03

Table 10. Adult Weevil Feeding on Needles in Burney Springs and Plummer Ridge Fields.

Date	No. Trees Sampled	Number feeding punctures on needles, 10 fascicles/tree 1949	1950
BURNEY SPRINGS FIELD			
7/28	80	988	7
PLUMMER RIDGE FIELD			
7/31			
East Block	25	725	18
West Block	25	350	8

2. Plummer Ridge Field. This series of tests was conducted with potted pine trees which were exposed to the spray mist during the field application of the insecticide. The trees were brought to the laboratory and covered with cylindrical cages covered with cheese cloth and supported by a wooden frame. Fifty weevils were introduced into each cage and mortality counts taken at the end of 24 and 48 hours. Untreated potted trees served as checks.

The rather low mortalities obtained are, perhaps, due to the fact that the insects did not move about freely, and many of them stayed on the walls of the cage for prolonged periods of time, thus avoiding contact with the DDT residue.

Another criterion may be that light, temperature and humidity conditions in the laboratory were not suitable for this test. Also, in at least one case, the mortality in the checks was rather high. Nevertheless, this test showed conclusively that the potted trees which were exposed to the spray mist in the open received larger quantities of the spray than those which were placed under the brush. See Table 11. The test also showed that two weeks after spraying the residues were as effective as when tested initially.

Table 11. Bioassay of Residual Effect of DDT on Cylindrocopturus eatoni (Buch.)

	Sample No.	SERIES I No. of Weevils	SERIES I No. dead Hrs. 24	SERIES I No. dead Hrs. 48	SERIES I % Mortality Hrs. 24	SERIES I % Mortality Hrs. 48	SERIES II No. of Weevils	SERIES II No. dead Hrs. 24	SERIES II No. dead Hrs. 48	SERIES II % Mortality Hrs. 24	SERIES II % Mortality Hrs. 48
West Field (covered)	4	50	2	8	4.0	16.0	50	4	8	8.0	16.0
	17	"	2	7	4.0	14.0	"	5	5	10.0	10.0
	18	"	4	6	8.0	12.0	"	2	5	4.0	10.0
	5	"	9	21	18.0	42.0	"	7	10	14.0	20.0
East Field (covered)	15	"	6	19	12.0	38.0	"	6	9	12.0	18.0
	11	"	10	22	20.0	44.0	"	5	11	10.0	22.0
	16	"	5	18	10.0	36.0	"	4	10	8.0	20.0
	14	"	15	26	30.0	52.0	"	11	18	22.0	36.0
	9	"	4	15	8.0	30.0	"	4	9	8.0	18.0
	Check	"	0	4	0.0	8.0	"	4	6	8.0	12.0
West Field (open)	2	"	25	42	50.0	84.0	"	11	22	22.0	44.0
	6	"	19	29	38.0	58.0	"	34	42	68.0	84.0
	12	"	26	41	52.0	82.0	"	16	27	32.0	54.0
	3	"	16	20	32.0	40.0	"	14	29	28.0	58.0
	13	"	20	30	40.0	60.0	"	10	21	20.0	42.0
East Field (open)	8	"	28	42	56.0	84.0	"	27	36	54.0	72.0
	1	"	19	33	38.0	66.0	"	18	35	36.0	70.0
	7	"	24	28	48.0	56.0	"	21	36	42.0	72.0
	10	"	16	28	32.0	56.0	"	28	42	56.0	84.0
	Check	"	4	10	8.0	20.0	"	5	12	10.0	24.0

D. Reduction in Loss.

A loss survey to determine the 1950 tree mortality was conducted in the Burney Springs field on March 30, 1951 and in the Plummer Ridge field on April 19, 1951. This showed a very satisfactory loss reduction, presumably resulting from the control action in both areas. The results, however, were very much better in the Burney Springs field than in the Plummer Ridge area. Average loss reduction in the Burney Springs field was 95.1% ± 3.2% at the 95% confidence level and was 86.5% ± 4.0% in the Plummer Ridge field. See tables 12 and 13.

Table 13. Reduction in Loss in the Plummer Ridge Field

WEST FIELD

	Row 1					Row 2						Row 3				Row 4					Row 5						
	A	B	C	D	E	A	B	C	D	E	F	A	B	C	D	A	B	C	D	E	A	B	C	D	E	F	Total
Living	10	10	10	10	10	10	7	4	10	10	10	10	2	0	10	6	3	10	10	10	10	10	4	10	10	10	216
Killed '49	5	0	7	4	5	1	5	5	3	0	4	9	5	6	6	8	7	3	0	0	0	4	3	8	2	3	103
% killed '49	33	0	41	29	33	9	42	56	23	0	29	47	71	100	38	57	70	23	0	0	0	29	43	44	17	23	32
Killed '50	0	0	2	0	1	0	1	0	1	0	0	3	0	0	0	1	1	0	0	0	0	0	0	1	0	0	11
% Killed '50	0	0	20	0	10	0	13	0	9	0	0	23	0	0	0	14	25	0	0	0	0	0	0	9	0	0	5
Reduction in loss %	100	0	71	100	80	100	80	100	67	100	100	67	100	100	100	88	86	100	0	0	0	100	100	88	100	100	89.3

EAST FIELD

	A	B	C	D	E	A	B	C	D	E	F	A	B	C	D	E	F	A	B	C	D	E	Total	East & West
Living	10	9	10	10	10	10	10	10	7	10	10	10	10	10	10	10	10	10	10	10	10	7	213	429
Killed '49	0	10	8	2	1	0	1	7	10	7	0	1	7	0	0	0	0	0	0	0	3	10	67	170
% killed '49	0	53	44	17	9	0	9	41	58	41	0	9	41	0	0	0	0	0	0	0	23	58	24	27.7
Killed '50	0	1	1	0	1	0	0	4	0	1	0	0	1	0	0	0	0	0	0	0	1	2	12	23
% Killed '50	0	10	9	0	9	0	0	285	0	9	0	0	9	0	0	0	0	0	0	0	9	22	5	
Reduction in loss %	100	90	88	100	0	0	100	42	100	86	0	100	86	0	0	0	0	0	0	0	67	80	82.1	86.5

86.5% reduction in loss ± sampling error of 4.0% at 95% level.

Table 14. Summary of Effectiveness of Spray in Burney Springs and Plummer Ridge Fields.

	Burney Springs Field	Plummer Ridge Field West Block	Plummer Ridge Field East Block
Average Effective Dosage* lbs./acre	.570	.392	.291
Average number adult weevils per tree	.13	.44	.52
No. feeding punction/fascicle	7	8	18
Reduction in Loss %	95.1	86.5	82.1

* Amount of deposit recovered from glass slides.

THE HELICOPTER VERSUS THE FIXED-WING AIRCRAFT

This experiment was not designed to show the relative value of the helicopter compared to the fixed-wing type of aircraft in applying DDT for the control of a forest insect pest. It is possible only to speculate on the relative merits of the two. From the standpoint of cost, the helicopter job was about double that for a fixed-wing job, based on estimates from bids submitted. The big question is whether the helicopter is twice as effective as the fixed wing in this type of control. The only basis of comparison we have is the airplane spray job on the same insect under somewhat comparable conditions in the Shasta brushfield during the spring of 1947. In many respects the Shasta job was conducted under much more favorable conditions. The principal point of difference was the more effective timing so that a large proportion of the adult weevils were subjected to direct contact with the spray in the case of the airplane job. On the helicopter job the only action possible was the residual effect. It appears that the same dosage applied from the helicopter gives superior residual effect over that applied from the fixed-wing craft. The reduction in loss for the helicopter test shows it to be about the same as the airplane test, but it must be remembered that a very high percentage of the total population was killed by contact in the plane test and not any in the helicopter test.

From the standpoint of coverage per hour of flying time in a comparison of the Shasta job with the Burney Springs job, we find that the fixed-wing craft, carrying a load of 50 gallons, covered an average of 141 acres per

hour, compared to the helicopter, carrying a 25-gallon load and covering an average of 126 acres per hour.

Again on a speculative basis, it is the opinion of the writers, that the helicopter could do a job comparable to the fixed-wing craft with only half the spray material. Even if this were true there would still be quite a differential in cost favoring the fixed wing. It would appear desirable at some future date to test these machines out, one against the other, under comparable conditions, because that is the only way to arrive at the answer.

SUMMARY

An experimental control project, using a helicopter to apply DDT spray, was undertaken against the reproduction weevil, in early June 1950, by the U. S. Forest Service, with technical assistance by the Berkeley Forest Insect Laboratory. This experiment was carried out on a 546-acre portion of the Burney Springs brushfield planting, on the Lassen National Forest and in two small brushfield plantings totaling 60 acres on Plummer Ridge on the Eldorado National Forest. In both of these areas the reproduction weevil had caused very serious damage in 1949 and threatened to continue its depredations in 1950 unless controlled. The formula of 1 lb. of DDT plus .333 gal. of solvent, plus. 667 gal. of diesel was used and applied at varying rates from 1/2 to 2 lbs. of DDT per acre. This was applied by a Bell, B-3, Model 47D, 178 h.p. helicopter owned by the A. F. Helicopters, Inc. and piloted by J. N. Newcomb. It was originally planned to time the application to coincide with the period of peak emergence of the weevil, but it became necessary to combine this job

with one for the control of sage brush through the application of 2-4-D, in which the same ship was used. This resulted in the spray being applied about two weeks prior to peak emergence and the spray results were entirely due to the residual action of DDT with no contact kill possible. The following control results were achieved:

1. Populations of adult weevils were apparently reduced to a very low level of about 1 weevil per ten trees in the Burney Springs planting, and about 1 weevil per two trees on the Plummer Ridge planting. The expected population of weevils, if no control had been carried on, was from 20 to 50 per tree.

2. Feeding on the needles by the adult weevils was reduced from an average of about 1.2 feeding punctures per needle in 1949 to 1 feeding puncture for every 100 needles in 1950 in the Burney Springs area. The results on the Plummer Ridge area was an average of about 2 feeding punctures per needle in 1949 reduced to 1 feeding puncture for every 20 needles in 1950.

3. The residual action of DDT on weevils caged with twigs from sprayed trees, under laboratory conditions failed to show the striking control action apparently obtained.

4. The average amount of recovered spray from glass slide tests in the Burney Springs field was 57% of .57 lb. per acre. It was 29% or .29 lb. per acre in the east field at Plummer Ridge and 20% or .39 lb. per acre in the west field.

5. The reduction in loss in the Burney Springs area averaged about 95% and 86% in the Plummer Ridge Area. See Table 14.